CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-31 – APPLIED MECHANICS

TUESDAY, 13 DECEMBER 2011

1315 - 1615 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by colleges:

Candidate's examination workbook
Graph paper

APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A steel bar, 50 mm diameter and 300 mm long is placed between two supports with an end clearance of 0.3 mm. The temperature is then increased by 180°C.

   Calculate EACH of the following:

   (a) the direct stress in the bar if the supports are perfectly rigid; (6)

   (b) the direct stress in the bar if the supports are elastic and the movement of one support relative to the other is 1μm per kN of force applied to them. (10)

   Note: *Modulus of Elasticity for Steel = 200 GN/m*^{2}
   Coefficient of Linear Elasticity for Steel = 11 μ*m/m°C*

2. A weather balloon of total mass 18 kg is at a height of 120 m and moving vertically upwards at a constant velocity of 6 m/s when an instrument module of mass 2 kg breaks free.

   Calculate EACH of the following:

   (a) the time taken for the module to reach the ground; (4)

   (b) the velocity at which the module strikes the ground; (4)

   (c) the subsequent acceleration of the balloon. (8)

3. A hollow shaft transmits 110 kW at 1800 rev/min. The shaft is 1.5 m long and has an outside diameter of 50 mm and an internal diameter of 36 mm.

   Calculate EACH of the following:

   (a) the angle of twist, in degrees, between each end of the shaft; (8)

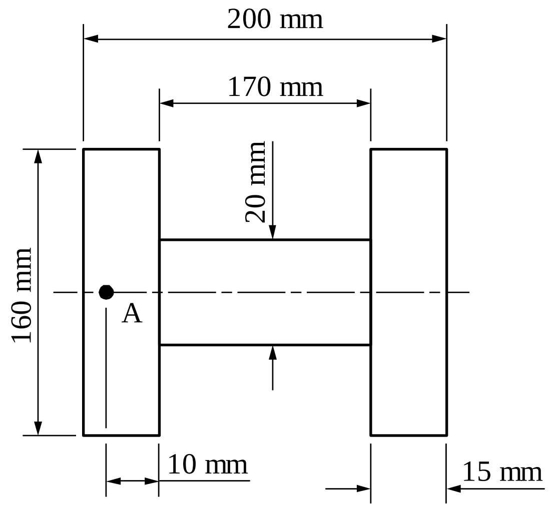
   (b) the maximum torsional stress in the shaft, stating where it occurs; (4)

   (c) the minimum torsional stress in the shaft, stating where it occurs. (4)

   Note: Modulus of Rigidity for shaft material = 82 GN/m^2.

4. A short vertical column with the <u>horizontal</u> cross section shown in Fig Q4 has a central vertical compressive load of 120 kN.

Calculate the maximum additional vertical load that can be placed at point A without producing tensile stress at any part of the section. (16)



Horizontal cross section
(not to scale)

5. A circular flywheel of mass 28 kg is fixed to a horizontal shaft of mass 8 kg and 40 mm diameter which is free to rotate in its bearings against a constant friction torque of 2.1 Nm.

A light cord is wound around the shaft and a mass of 18 kg is suspended at the free end of the cord. When the system is released from rest the mass descends 1.2 m in 16 seconds with uniform acceleration.

Calculate EACH of the following:

(a) the moment of inertia of the flywheel and shaft assembly; (13)

(b) the radius of gyration of the flywheel and shaft assembly. (3)

Fig Q4

6. A circular cam rotates at 360 rev/min and is offset from the centre of rotation by 14 mm. The cam follower has a mass of 0.6 kg and moves with simple harmonic motion.

Calculate EACH of the following:

(a) the maximum velocity of the cam follower; (3)

(b) the maximum acceleration of the cam follower; (3)

(c) the velocity of the cam follower at ¾ lift; (4)

(d) the speed at which the inertia force on the cam follower would be equal to its own weight. (6)

7. A tank containing lubricating oil of relative density 0.88 has two outlet orifices on one side of the tank. The upper orifice is 16 mm diameter and has its centre 1.4 m below the oil surface. The lower orifice is 22 mm diameter and has its centre 3.0 m below the oil surface. Oil is supplied to the tank at 2 kg/s to maintain a constant oil level in the tank.

Calculate EACH of the following:

(a) the mass flow rate of oil from the 16 mm diameter orifice; (8)

(b) the coefficient of velocity for the 22 mm diameter orifice. (8)

Note: *For 16 mm diameter orifice:* *coefficient of velocity* = 0.98
coefficient of contraction = 0.68

For 22 mm diameter orifice: *coefficient of contraction* = 0.68

8. A basic flapper/nozzle device is shown in Fig Q8. The pneumatic signal for the input bellows unit is proportional to the measured temperature within the range 0-150°C. The output signal range is to be 20-100 kN/m^2.

The characteristic of the input bellows is 4 μm/^{0}C, and the characteristic of the nozzle is 0.2 kN/m^2 per μm of flapper movement.

Calculate EACH of the following:

(a) the flapper movement at the nozzle for 100% input change; (2)

(b) the resulting change in output; (2)

(c) the gain of the device; (2)

(d) the new setting of *x*, the distance from the pivot to the nozzle, to achieve a gain of 0.5; (5)

(e) the output pressure at 85^{0}C with a gain of 0.5 if the output pressure was 50 kN/m^2 at a temperature of 55^{0}C. (5)

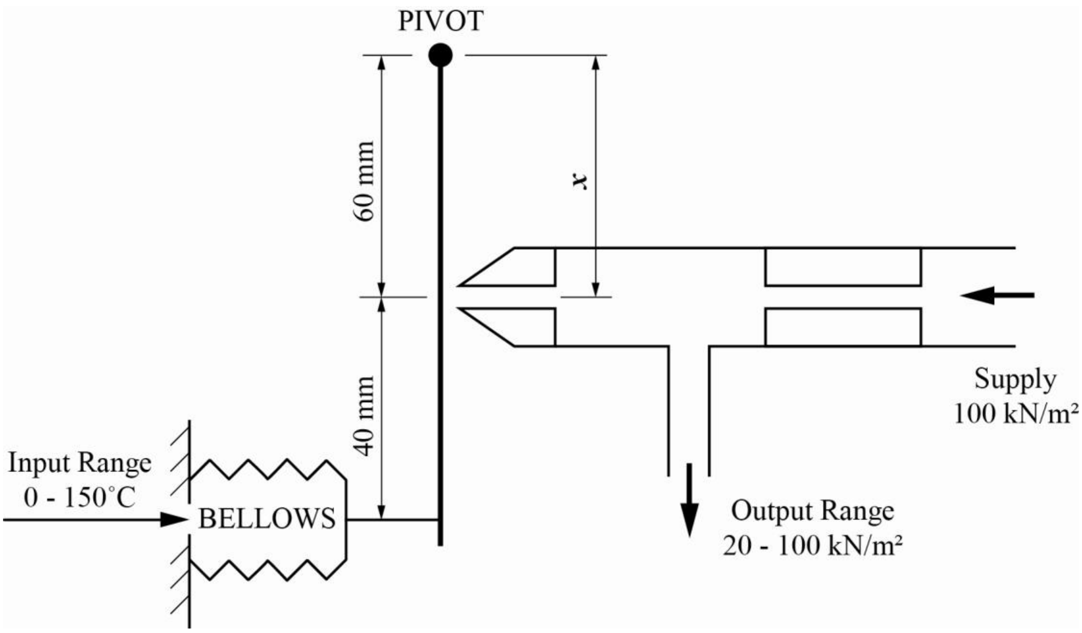


Fig Q8

9. A pump has a suction lift of 400 mm and it delivers 110 tonnes of sea water per hour to a height of 8 m above the pump discharge.

The delivery pipe has a diameter of 160 mm and is 36 m long. The friction coefficient for Darcy's formula is 0.01. Friction and Kinetic Energy in the suction pipe may be ignored.

Calculate EACH of the following:

(a) the power output of the pump; (10)

(b) the pressure at the pump discharge. (6)

Note: Density of Sea Water = 1025 kg/m^3